9

Japanese Kokai Patent Application No. Hei 9[1997]-41135

UL VAC

Translated from Japanese by the Ralph McElroy Translation Company
910 West Avenue, Austin, Texas 78701 USA

Code: 598-75072
Ref: 2390/MD/L/B/MBE-3600

JAPANESE PATENT OFFICE
PATENT JOURNAL (A)
KOKAI PATENT APPLICATION NO. HEI 9[1997]-41135

| | |
|---|---|
| Int. Cl.[6]: | C 23 C 14/35<br>//C 23 C 14/34 |
| Filing No.: | Hei 7[1995]-191762 |
| Filing Date: | July 27, 1995 |
| Publication Date: | February 10, 1997 |
| No. of Claims: | 1 (Total of 5 pages; OL) |
| Examination Request: | Not filed |

# MAGNETRON SPUTTERING CATHODE

| | |
|---|---|
| Inventors: | Seiichi Takahashi<br>Ulvac Corporation<br>2500 Ogisono, Chigasaki-shi,<br>Kanagawa-ken |
| | Yasu Mizuzawa<br>Fuji Susono Works<br>Ulvac Corporation<br>1220-14 Suyama, Susono-shi,<br>Shizuoka-ken |
| | Tomoyasu Kondo<br>Fuji Susono Works<br>Ulvac Corporation<br>1220-14 Suyama, Susono-shi,<br>Shizuoka-ken |

Hiroharu Mizuya
Kogoshima Works
Alpac Kyushu Co., Ltd.
3313 Yokogawa-cho, Aira-gun,
Kogashima-ken

Applicant: 000231464
Ulvac Corporation
2500 Ogisono, Chigasaki-shi,
Kanagawa-ken

Agent: Shigeru Yagida, patent attorney,
and 3 others

[There are no amendments to this patent.]

Abstract

Problem

The purpose of this invention is to provide a type of magnetron sputtering cathode that can perform discharge even at a low pressure and has a high target utilization efficiency.

Means to solve

This invention provides a magnetron sputtering cathode characterized by the following facts: on the back side of the target, a magnet device is set; the magnet device has the circumference of an inner ring-shaped magnet surrounded by an outer ring-shaped magnet in a ring configuration with a prescribed gap between the inner ring-shaped magnet and the outer ring-shaped magnet; a curved magnetic field is formed by the magnet device in the space near the surface of the target; in this magnetron sputtering cathode, the gap between the inner ring-shaped magnet and outer ring-shaped magnet of the magnet device is modulated such that the curved magnetic field formed in the space near the surface of the target is also modulated.

Claim

A type of magnetron sputtering cathode characterized by the following facts: on the back side of the target, a magnet device is set; the magnet device has the circumference of an inner ring-shaped magnet surrounded by an outer ring-shaped magnet in a ring configuration with a prescribed gap between the inner ring-shaped magnet and the outer ring-shaped magnet; a curved magnetic field is formed by the magnet device in the space near the surface of the target; in this magnetron sputtering cathode, the gap between the inner ring-shaped magnet and outer ring-

shaped magnet of the magnet device is modulated such that the curved magnetic field formed in the space near the surface of the target is also modulated.

Detailed explanation of the invention

[0001]

Technical field of the invention

This invention pertains to a type of magnetron sputtering cathode that can perform discharge even at a low pressure.

[0002]

Prior art

Figures 5, 6 and 7 illustrate a conventional magnetron sputtering cathode. As shown in Figures 5 and 6, target (1) is mounted on the surface of target electrode (2), and magnet device (3) is set on the back of target electrode (2). Magnet device (3) comprises magnet plate (4) having a circular plate shape, circular inner ring-shaped magnet (5) set on said magnet plate (4), and circular outer ring-shaped magnet (6) set to surround the circumference of said inner ring-shaped magnet (5) with a prescribed gap from said inner ring-shaped magnet (5) in a ring configuration. The polarity of the tip of inner ring-shaped magnet (5) adjacent to target electrode (2) and the polarity of the tip of outer ring-shaped magnet (6) adjacent to target electrode (2) are opposite to each other. As shown in Figure 7, rod magnets (7) are set side by side in a ring shape. The two opened ends of each rod magnet form N-pole and S-pole, respectively.

[0003]

As shown in Figures 5 and 6, (8) represents a mechanism for rotating or scanning magnet device (3). (9) represents a DC power source for applying a negative voltage on target electrode (2). (10) represents a vacuum container having discharge gas feed-in port (11) and evacuating port (12). (13) represents a substrate set facing target (1) in vacuum container (10). (14) represents a substrate holder on which heater (15) is set.

[0004]

For this magnetron sputtering cathode, suppose the tip of inner ring-shaped magnet (5) adjacent to target electrode (2) is N-pole, and the tip of outer ring-shaped magnet (6) adjacent to target electrode (2) is S-pole, the magnetic field lines flowing out from the tip of inner ring-shaped magnet (5) adjacent to target electrode (2) are curved in the space near the surface of target (1), and they then flow into the tip of outer ring-shaped magnet (6) adjacent to target

electrode (2), thus forming a curved magnetic field in the space near the surface of target (1). Then, while the interior of vacuum container (10) is evacuated, the discharge gas is fed into it such that the pressure in vacuum container (10) is kept steady at $10^{-1}$ Pa. As a negative voltage is applied from DC power source (9) to target electrode (2), discharge takes place in the region where the curved magnetic field is formed in the space near the surface of target (1), target (1) is exposed to the discharge, and sputtering is carried out by the ions in the discharge.

[0005]

Problem to be solved by the invention

For the conventional magnetron sputtering cathode, as explained above, the gap between inner ring-shaped magnet (5) and outer ring-shaped magnet (6) is constant, and the magnet is formed by setting rod magnets side by side. Consequently, the intensity of the curved magnetic field formed in the space near the surface of target (1) remains constant. Consequently, when the vacuum level in vacuum container (10) is as low as 1 x $10^{-1}$ Pa or lower in a certain pressure 0.75 r region, the intensity of the magnetic field needed to start the discharge may become insufficient, so that even when a negative bias voltage is applied from power source (9) to target electrode (2), discharge still cannot take place. This is a problem. According to studies made by us, the relationship between the discharge start pressure and the magnetic field intensity is shown in Figure 4. However, it has been confirmed that [by adopting the method of this invention,] discharge can take place under conditions not in the discharge region shown in Figure 4.

[0006]

When magnets with a higher magnetic field intensity are used or the diameter of inner ring-shaped magnet (5) or outer ring-shaped magnet (6) is changed, the gap between inner ring-shaped magnet (5) and outer ring-shaped magnet (6) becomes smaller and the curved magnetic field formed in the space near the surface of target (1) becomes higher. In this case, it is possible to perform discharge even when the pressure in vacuum container (10) is as low as 1 x $10^{-1}$ Pa or lower. However, in the former, there is a limit on the high-power magnets that can be procured. In the latter method, as the region where the curved magnetic field is formed in the space near the surface of target (1) becomes narrower, the region where discharge can take place in the space near the surface of target (1) becomes narrower. Consequently, the region where target (1) can be exposed to the discharge becomes narrower. In other words, the erosion region becomes narrower and the efficiency of target utilization (1) becomes very poor. This is a new problem.

[0007]

The purpose of this invention is to solve the aforementioned problems of the conventional technology by providing a magnetron sputtering cathode that can perform discharge even at a low pressure and has a high target utilization efficiency.

[0008]

Means to solve the problem

In order to solve the aforementioned problem, this invention provides a type of magnetron sputtering cathode characterized by the following facts: on the back side of the target, a magnet device is set; the magnet device has the circumference of an inner ring-shaped magnet surrounded by an outer ring-shaped magnet in a ring configuration with a prescribed gap between the inner ring-shaped magnet and the outer ring-shaped magnet; a curved magnetic field is formed by the magnet device in the space near the surface of the target; in this magnetron sputtering cathode, the gap between the inner ring-shaped magnet and outer ring-shaped magnet of the magnet device is modulated such that the curved magnetic field formed in the space near the surface of the target is also modulated.

[0009]

Function

According to this invention, the gap between the inner ring-shaped magnet and outer ring-shaped magnet of the magnet device is modulated such that the intensity of the curved magnetic field formed in the space near the surface of the target is undulated. Consequently, in the portion where the gap between the inner ring-shaped magnet and outer ring-shaped magnet becomes smaller, the intensity of the curved magnetic field formed in the space near the surface of the target is increased. Consequently, discharge can take place in this portion, even at a low pressure. This discharge spreads along the magnetic field, so that discharge can take place even in the portion where the gap between the inner ring-shaped magnet and outer ring-shaped magnet is larger and the intensity of the curved magnetic field formed in the space near the surface of the target is lower.

[0010]

Also, as the region where the curved magnetic field formed in the space near the surface of the target becomes larger, the discharge region near the surface of the target becomes larger and the target utilization efficiency is increased.

[0011]

Embodiment of the invention

In the following, the embodiment of this invention will be explained with reference to application examples illustrated by figures.

Application examples

Figures 1 and 2 illustrate the magnetron sputtering cathode in Application Example 1 of this invention. It is an improvement over the conventional magnetron sputtering cathode. As shown in these figures, target (21) is mounted on the surface of target electrode (22). Also, magnet device (23) is set on the back of target electrode (22). Magnetic device (23) comprises magnet plate (24) having a circular plate shape, circular inner ring-shaped magnet (25) set on said magnet plate (24) and having its central axis deviated from the central axis of said magnet plate (24), and circular outer ring-shaped magnet (26) set to surround the circumference of said inner ring-shaped magnet (25) in a ring configuration with a narrower gap from inner ring-shaped magnet (25) on the circumferential [sic, inner] side of magnet plate (24) and a wider gap from inner ring-shaped magnet (25) on the outer side of magnet plate (24). The polarity of the tip of inner ring-shaped magnet (25), adjacent to target electrode (22), is N-pole, and the polarity of the tip of outer ring-shaped magnet (26), adjacent to target electrode (22), is S-pole.

[0012]

Figure 3 is a diagram illustrating Application Example 2 of this invention. As shown in this figure, the circumference of inner ring-shaped magnet (25) is surrounded by outer ring-shaped magnet (26) in a ring configuration on magnet plate (24) with a wider gap between the outer ring-shaped magnet and inner ring-shaped magnet (25) on the inner side of magnet plate (24) and a narrower gap between the outer ring-shaped magnet and inner ring-shaped magnet (25) on the outer side of magnet plate (24).

[0013]

In said Application Examples 1 and 2, the gap between inner ring-shaped magnet (25) and outer ring-shaped magnet (26) is modulated such that the intensity of the curved magnetic field formed in the space near the surface of target (21) is also modulated. Consequently, in the portion where the gap between inner ring-shaped magnet (25) and outer ring-shaped magnet (26) of magnet device (23) is narrower, the intensity of the curved magnetic field formed in the space near the surface of target (21) becomes higher, so that discharge can take place even at a low pressure. Then, the discharge becomes a seed of discharge and it spreads along the magnetic field such that discharge can take place even in the portion where the gap between inner ring-

shaped magnet (25) and outer ring-shaped magnet (26) is wider and the intensity of the curved magnetic field formed in the space near the surface of target (21) is lower.

[0014]

Also, as the region where the curved magnetic field formed in the space near the surface of target (21) becomes larger, the region where discharge can take place in the space near target (21) becomes wider. Consequently, the portion of target (21) that can be exposed to the discharge becomes larger and the utilization efficiency of target (21) becomes higher.

[0015]

For example, suppose, for the portion where the gap between inner ring-shaped magnet (25) and outer ring-shaped magnet (26) is narrower such that the intensity of the curved magnetic field formed in the space near the surface of target (21) is higher, the intensity of the horizontal magnetic field is 53 mT (milli-Tesla), and suppose, for the portion where the gap between inner ring-shaped magnet (25) and outer ring-shaped magnet (26) is wider such that the intensity of the curved magnetic field formed in the space near the surface of target (21) is lower, the intensity of the horizontal magnetic field is 35 mT. In this case, discharge can take place even when the pressure in the vacuum container is as low as 5 x $10^{-2}$ Pa. This is indicated by the fact that in Figure 4, the relationship between the intensity of the horizontal magnetic field of the curved magnetic field formed in the space near the surface of target (21) and the pressure in the vacuum container at which the discharge can take place is not met, yet by modulating the gap between the magnets, it is possible to realize discharge easily at a lower pressure. -37-

[0016]

In the aforementioned application examples, inner ring-shaped magnet (25) and outer ring-shaped magnet (26) of magnet device (23) have a circular shape. However, the shape may be other than circular.

[0017]

Effect of the invention

As explained above, according to this invention, the gap between the inner ring-shaped magnet and outer ring-shaped magnet of the magnet device is modulated such that the intensity of the curved magnetic field formed in the space near the surface of the target is modulated. Consequently, for the portion where the gap between the inner ring-shaped magnet and the outer ring-shaped magnet is narrower, the intensity of the curved magnetic field formed in the space near the surface of the target is higher. Therefore, discharge can take place even at a low

pressure. The discharge acts as a seed discharge and spreads along the magnetic field. As a result, discharge also takes place in the portion where the gap between the inner ring-shaped magnet and the outer ring-shaped magnet is wider and the intensity of the curved magnetic field formed in the space near the surface of the target is lower.

[0018]

Also, the region where the curved magnetic field formed in the space near the surface of the target becomes larger, and the region where discharge takes place in the space near the surface of the target becomes wider. Consequently, the portion of the target that is exposed to the discharge becomes larger, and the utilization rate of the target becomes higher.

Brief description of the figures

Figure 1 is a cross-sectional view of Application Example 1 of this invention.

Figure 2 is a cross-sectional view taken across A-A in Figure 1.

Figure 3 is a diagram illustrating the main portion of Application Example 2 of this invention.

Figure 4 is a graph illustrating the relationship between the intensity of the horizontal magnetic field of the curved magnetic field formed in the space near the surface of the target and the pressure in the vacuum container at which discharge can take place.

Figure 5 is a cross-sectional view of a conventional magnetron sputtering cathode.

Figure 6 is a cross-sectional view taken across B-B in Figure 4.

Figure 7 is a schematic diagram illustrating the main portion of another example of the conventional magnetron sputtering cathode.

Explanation of symbols

21 Target
22 Target electrode
23 Magnet device
24 Magnet plate
25 Inner ring-shaped magnet
26 Outer ring-shaped magnet

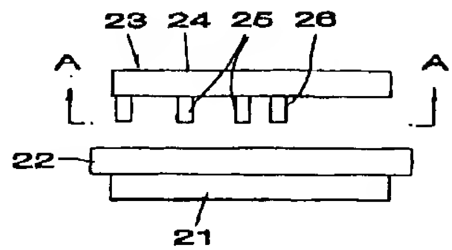


Figure 1

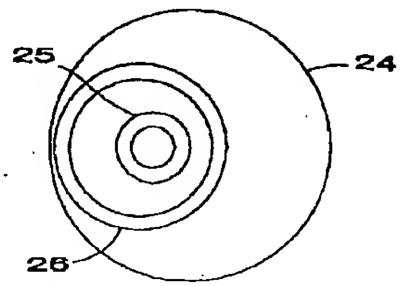


Figure 2

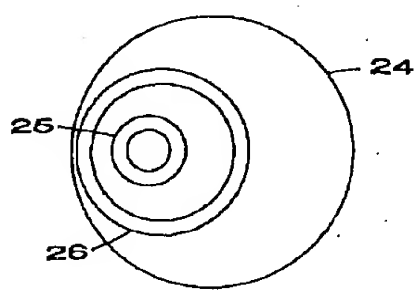


Figure 3

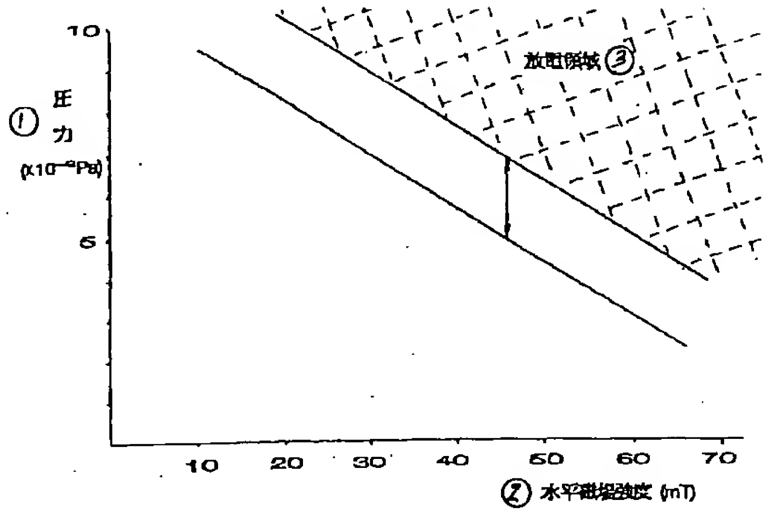


Figure 4

Key: 1 Pressure
2 Horizontal magnetic field intensity
3 Discharge region

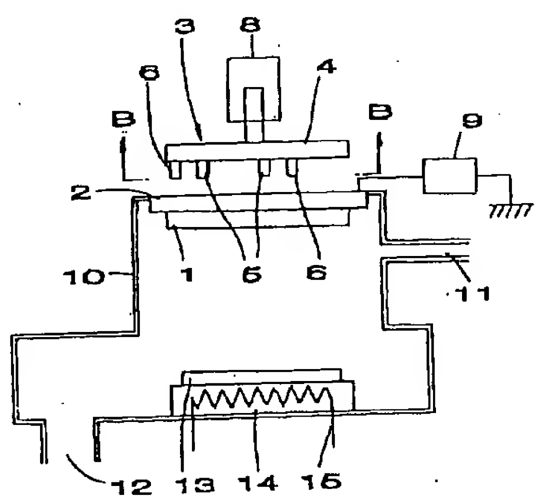


Figure 5

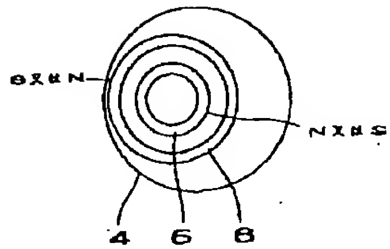


Figure 6

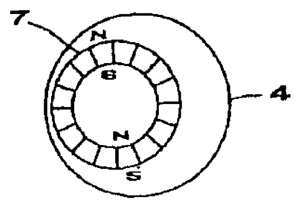


Figure 7